Video Article

Biocontained Carcass Composting for Control of Infectious Disease Outbreak in Livestock

Tim Reuter[1], Weiping Xu[2], Trevor W. Alexander[1], Brandon H. Gilroyed[1], G. Douglas Inglis[1], Francis J. Larney[1], Kim Stanford[3], Tim A. McAllister[1]

[1]Agriculture and Agri-Food Canada, Lethbridge Research Centre
[2]Department of Bioscience and Biotechnology, Dalian University of Technology
[3]Agriculture Centre, Alberta Agriculture and Rural Development

Correspondence to: Tim A. McAllister at tim.mcallister

URL: http://www.jove.com/details.php?id=1946

DOI: 10.3791/1946

Citation: Reuter T., Xu W., Alexander T.W., Gilroyed B.H., Inglis G.D., Larney F.J., Stanford K., McAllister T.A. (2010). Biocontained Carcass Composting for Control of Infectious Disease Outbreak in Livestock. JoVE. 39. http://www.jove.com/details.php?id=1946, doi: 10.3791/1946

Abstract

Intensive livestock production systems are particularly vulnerable to natural or intentional (bioterrorist) infectious disease outbreaks. Large numbers of animals housed within a confined area enables rapid dissemination of most infectious agents throughout a herd. Rapid containment is key to controlling any infectious disease outbreak, thus depopulation is often undertaken to prevent spread of a pathogen to the larger livestock population. In that circumstance, a large number of livestock carcasses and contaminated manure are generated that require rapid disposal.

Composting lends itself as a rapid-response disposal method for infected carcasses as well as manure and soil that may harbor infectious agents. We designed a bio-contained mortality composting procedure and tested its efficacy for bovine tissue degradation and microbial deactivation. We used materials available on-farm or purchasable from local farm supply stores in order that the system can be implemented at the site of a disease outbreak. In this study, temperatures exceeded 55°C for more than one month and infectious agents implanted in beef cattle carcasses and manure were inactivated within 14 days of composting. After 147 days, carcasses were almost completely degraded. The few long bones remaining were further degraded with an additional composting cycle in open windrows and the final mature compost was suitable for land application.

Duplicate compost structures (final dimensions 25 m x 5 m x 2.4 m; L x W x H) were constructed using barley straw bales and lined with heavy black silage plastic sheeting. Each was loaded with loose straw, carcasses and manure totaling ~95,000 kg. A 40-cm base layer of loose barley straw was placed in each bunker, onto which were placed 16 feedlot cattle mortalities (average weight 343 kg) aligned transversely at a spacing of approximately 0.5 m. For passive aeration, lengths of flexible, perforated plastic drainage tubing (15 cm diameter) were placed between adjacent carcasses, extending vertically along both inside walls, and with the ends passed though the plastic to the exterior. The carcasses were overlaid with moist aerated feedlot manure (~1.6 m deep) to the top of the bunker. Plastic was folded over the top and sealed with tape to establish a containment barrier and eight aeration vents (50 x 50 x 15 cm) were placed on the top of each structure to promote passive aeration. After 147 days, losses of volume and mass of composted materials averaged 39.8% and 23.7%, respectively, in each structure.

Protocol

Duplicate compost structures were constructed at the Lethbridge Research Centre (LRC) in Lethbridge, Alberta, Canada (Fig. 1). Large rectangular barley straw bales (260 x 120 x 80 cm; L x W x H) were used for the walls, and small bales (100 x 40 x 45 cm) for the floor. Large bales were oriented so walls were 120 cm thick, which maximized wall stability and heat retention. The small bales forming the floor were oriented with twine running horizontally to maximize absorbance in the event of a leak, yielding a floor 45 cm thick. Overall dimensions of the structures were 25 m x 5 m x 2.4 m; L x W x H). The construction site had a slope of approximately 1 , and the structures were oriented to encourage flow of leachate toward the sampling port that we inserted for experimental assessment. Moist feedlot manure was mixed and aerated by processing through a manure spreader and piling for 24 h prior to construction of the containment structures.

The compost bunkers were lined with heavy black/white plastic sheeting commonly used to cover silage piles. Sufficient surplus was left over the top in each direction to enable eventual fold-down and sealing of the compost bed within the bunker. To combat an ambient breeze, tires were used to weight the plastic in the bunker until the straw was loaded, but these were removed prior to the carcasses being placed. Once the leachate sampling port (necessary for experimental sampling only) was installed, loose barley straw was added into the bio-containment structure to form a base layer approximately 40 cm thick. This was accomplished by delivering a single round bale with a front end loader, and manually distributing the straw along the length of the bunker.

Sixteen feedlot cattle mortalities were placed onto the straw bed. These were cattle that had died within the previous 48 hours at nearby commercial feedlots, the majority having succumbed to bovine respiratory disease. The carcasses were aligned transversely within the composting bunker (Fig. 1), with a space of approximately 0.5 m between carcasses. To provide passive aeration, lengths of perforated flexible plastic drainage tubing (15 cm diameter) were laid between adjacent carcasses, embedded within the loose straw base. The ends of the tubing were directed vertically along the side walls extending beyond the top of the bunker, and held in place temporarily using tires extending past the upper surface of the walls.

Pre-conditioned feedlot manure was loaded into the bunkers to cover the carcasses to a final depth of 1.6 m. The manure was loaded over the side wall of the bunker, moving from one end of structure toward the other. The sample retrieval pyramids described below were positioned at their prescribed depths within the manure layer during this stage. Once the bunker was filled, the plastic sheeting was folded over the top of the piled manure and the ends of the perforated tubing were passed through it so that they were situated exterior to the wrap. The plastic was sealed with tape to establish a containment barrier around the straw, carcasses and manure. Eight aeration vents (50 x 50 x 15 cm) were placed on the top of each structure to promote passive aeration, and T-shaped connectors were attached to each end of the lengths of perforated tubing to promote air flow down into the tubes.

In this pilot study, experimental amendments to the compost structures were incorporated to enable investigation of pathogen inactivation and tissue degradation during the static composting process. Tissue and microbial samples pre-quantified by tissue weight or microbial enumeration were heat-sealed into nylon sample bags (5 x 9 cm; 50-µm pore size), and packed into specialized pyramidal steel cages, designated as Baker Retrieval Pyramids (BRP)[1]. These pyramids were designed to enable their retrieval from the compost matrix at intervals during the composting process without seriously compromising containment or altering the dynamics of the composting process Within a BRP, eight bags (one each of eight sample types) were embedded in the same manure that was used to fill the bunker, arranged so that each bag was surrounded by manure and no bags were in direct contact with one another. Manure- and bag-filled BRPs were attached to lengths of logging chain and suspended at depths of 80 cm and 160 cm within the compost matrix. The chains were anchored to wooden poles spanning the bunkers at 1.5-m intervals (Fig. 1). T-type thermocouples placed in each BRP were also run along the chains to a data logger positioned externally to the compost structure. At specified intervals, BRPs were withdrawn vertically from the compost using a ratcheted come-along cable puller, and the plastic wrap was re-sealed. In the naturally arid climate of southern Alberta, little rainfall was received during this period, but the plastic wrap and domed shape of the composting material were effective for promoting lateral runoff to be absorbed by the straw bunker walls.

Discussion

After 147 days of static composting, losses of total mass, dry matter (DM), organic matter, total carbon and total nitrogen were 23.7, 35.6, 52.9, 49.6, and 41.4%, respectively[2]. Within each structure, the volume of materials composted decreased from 118 to 71 m^3. Decomposition of the bovine tissues monitored ranked as brain > hoof > bone. After only 7 days of composting, >90% of brain tissue DM had decomposed, and 80% of hoof DM had decomposed within 56 d of composting. Complete loss of viability of *Escherichia coli* O157:H7 and Newcastle Disease was achieved within 14 days.

Intensive livestock production systems are particularly vulnerable to natural or intentional infectious disease outbreaks. Housing a large number of animals within a confined area gives rise to most infectious agents disseminating rapidly throughout the population. Containment is key to controlling any infectious disease outbreak, thus depopulation is used frequently as a means of preventing spread of the infectious agent to the larger livestock population. The depopulation scenario results in large numbers of livestock carcasses and contaminated manure requiring rapid disposal. Composting lends itself as a rapid-response disposal method for infected carcasses as well as manure and soil that may harbor infectious agents. We outline a composting procedure that can be conducted at the site of the disease outbreak, using materials readily available on-farm or from local farm-supply stores. In our study, infectious agents associated with beef cattle carcasses and manure were inactivated within 14 days of composting, an compost temperatures exceeded 55 °C for more than one month. Production of leachate was extremely low, likely to due the absorbent nature of the loose straw base layer and our having optimized the DM content at initiation of composting. Total yields of leachate were less than 3 ppm of the initial compost mass (i.e., <300 g per structure). Coliforms were detected in the leachate at up to 5.8 log10 CFU/mL at 14 days, but were not detectable after 101 days of composting. After 147 days, bovine carcasses were almost completely degraded with only a few long bones being recognizable. Bones were degraded further during the additional open-windrow composting cycle after the biocontained structures were opened, yielding final mature compost suitable for land application.

In conclusion, composting creates conditions that present substantial challenge to the survival of most pathogenic microorganisms. Free bacteria, protozoa and viruses are rapidly inactivated by the high temperature, alkalinity and high protease and nuclease activities within compost. This successful decomposition of mature feedlot cattle carcasses indicates that this static composting disposal procedure would be suitable for all common livestock. Care must be taken, however, to ensure that optimal carbon:nitrogen ratios and moisture levels are present in order for microbial kill conditions to be achieved. Pathogens inherently more heat-resistant, such as bacteria that form spores (e.g., anthrax), or those that are unusually recalcitrant, such as prions, may still remain infective after composting. Studies to elucidate the fate of these types of microorganisms during the composting process are currently underway in our laboratory.

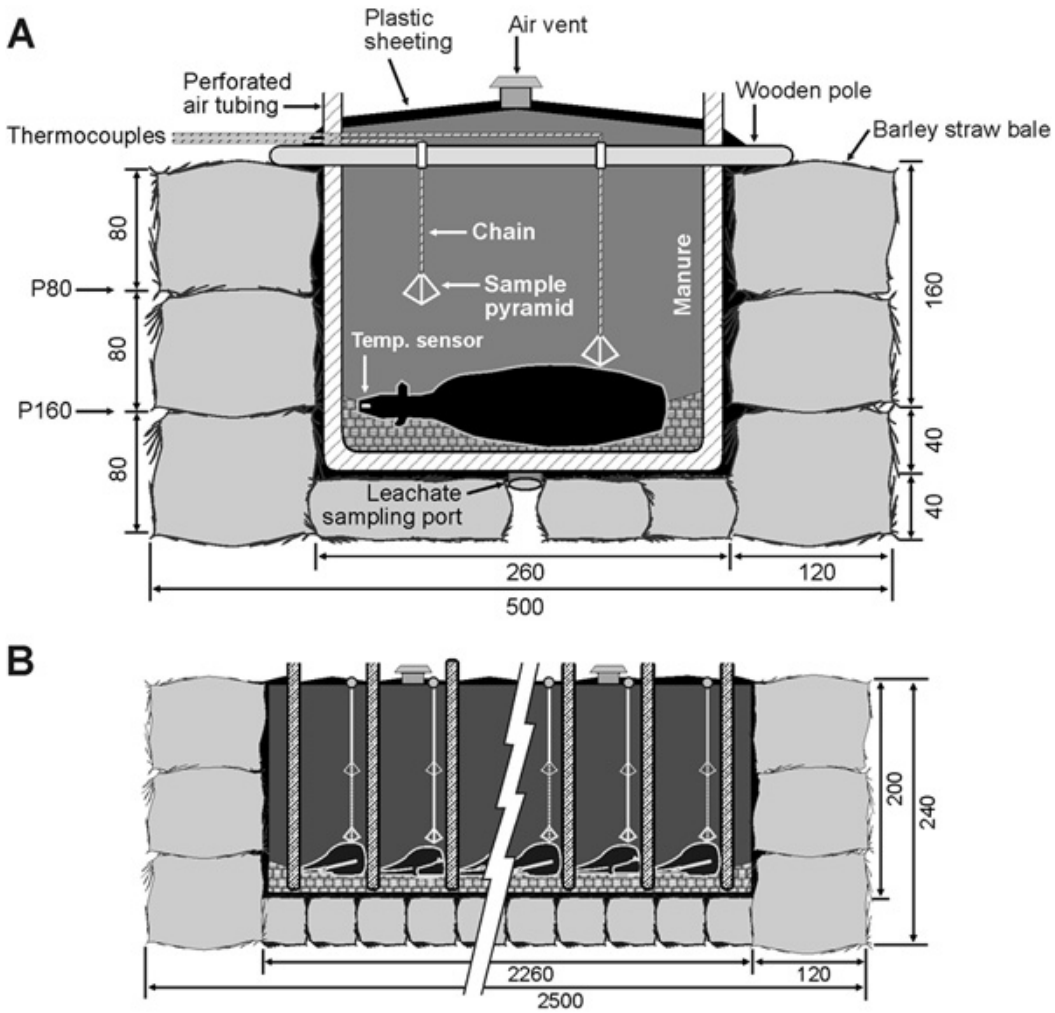

Figure 1. Diagrammatic representation of the biosecure compost system comprising straw bale walls and floor, plastic sheeting enclosure, loose straw base, cattle carcasses, manure, perforated plastic ventilation tubing, and air vents, as well as experimental amendments (leachate port, sample retrieval pyramids and temperature sensors. (A) Transverse view (cross section). (B) Longitudinal view (side wall removed). All dimensions are in cm. From Xu et al. (2009)[2]

Disclosures

No conflicts of interest declared.

Acknowledgements

This project was conducted with funding from the Chemical, Biological, Radiological and Nuclear (CBRN) Research and Technology Initiative (CRTI) of the Canadian Food Inspection Agency, and the Alberta Prion Research Institute. The National Natural Science Foundation of China provided a scholarship (No. 30620120430) to W. Xu. The authors thank Brant Baker and Fred Van Herk, as well as Ruth Barbieri, Lisa Kalischuk-Tymensen, Andrew Olson, Lorna Selinger, Geoff Wallins and Homayoun Zahiroddini for their technical assistance.

References

1. Reuter, T. *et al.* A simple method for temporal collection of tissue and microbial samples from static composting systems. *Canadian Biosystems Engineering* **50**, 6.17 - 6.20 (2008).
2. Xu, W. *et al.* A biosecure composting system for disposal of cattle carcasses and manure following infectious disease outbreak. *J. Environ. Qual.* **38**, 437-450 (2009).

